Roller Press

1. INTRODUCTION

The roller press is a relatively new development in the cement manufacturing process. This efficient comminution machine is applied mainly for clinker but is also used for raw material and slag. The size reduction of the material takes place under high pressure between two rotating rollers.

The press can be installed in combination with a tube mill (new installation or expansion of an existing mill) or as a finish grinding system.

2. GENERAL DESIGN AND WORKING PRINCIPLE

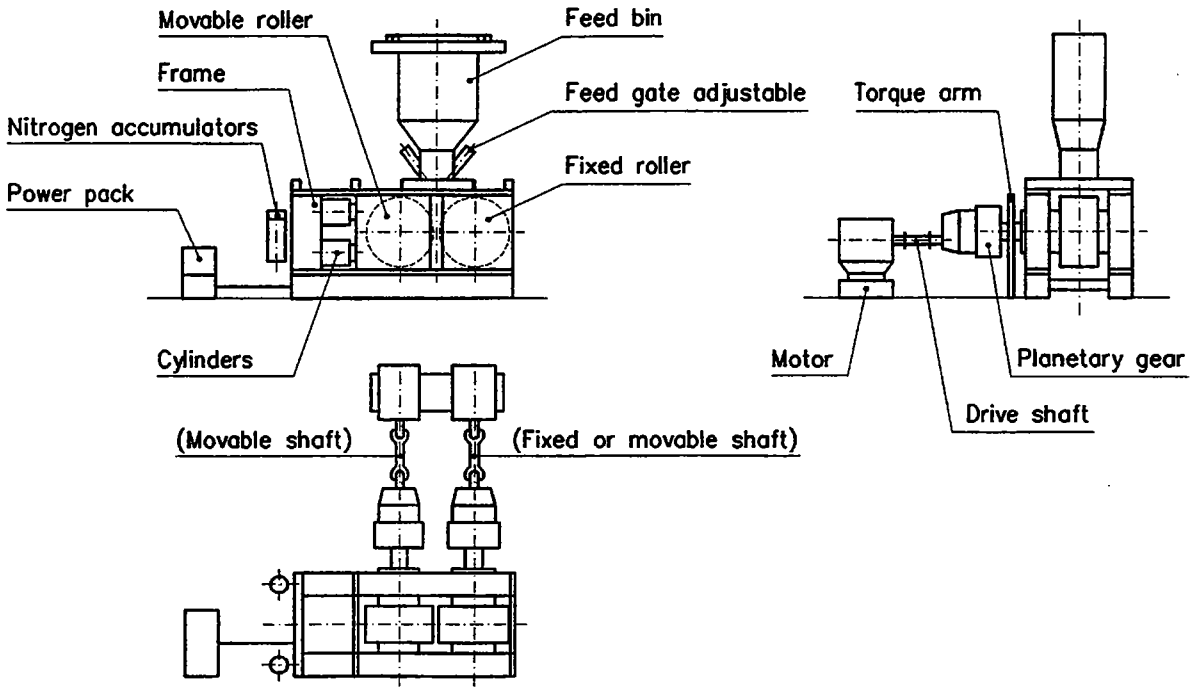
2.1 General Design (Figure 1)

The design of the roller press is dependent on the supplier, however, the basic construction is very similar for all makes.

The main elements are:

- Press frame
- Pair of rollers
  - One fixed roller
  - One movable roller
  - Each complete roller consists of the roller body with wear protection, two rolling bearings and two sliding blocks (bearing housings). The lubrication can either be by oil or grease. The rollers can be with/without water cooling.
- Rollerdrive (two units)
  - Planetary gear with torque arm
  - Drive shaft (fixed or movable)
  - Electric motor (fixed or variable speed)
- Hydraulic system
  - Cylinders (two or four)
  - Nitrogen accumulators (two or several)
  - Power pack consisting of oil tank, pump, motor and valves

Figure 1 General Design



- Feed bin with level indicator or load cells (not part of the press)
- Adjustable feed gate

The area around the rollers is covered in order to prevent dust emission.

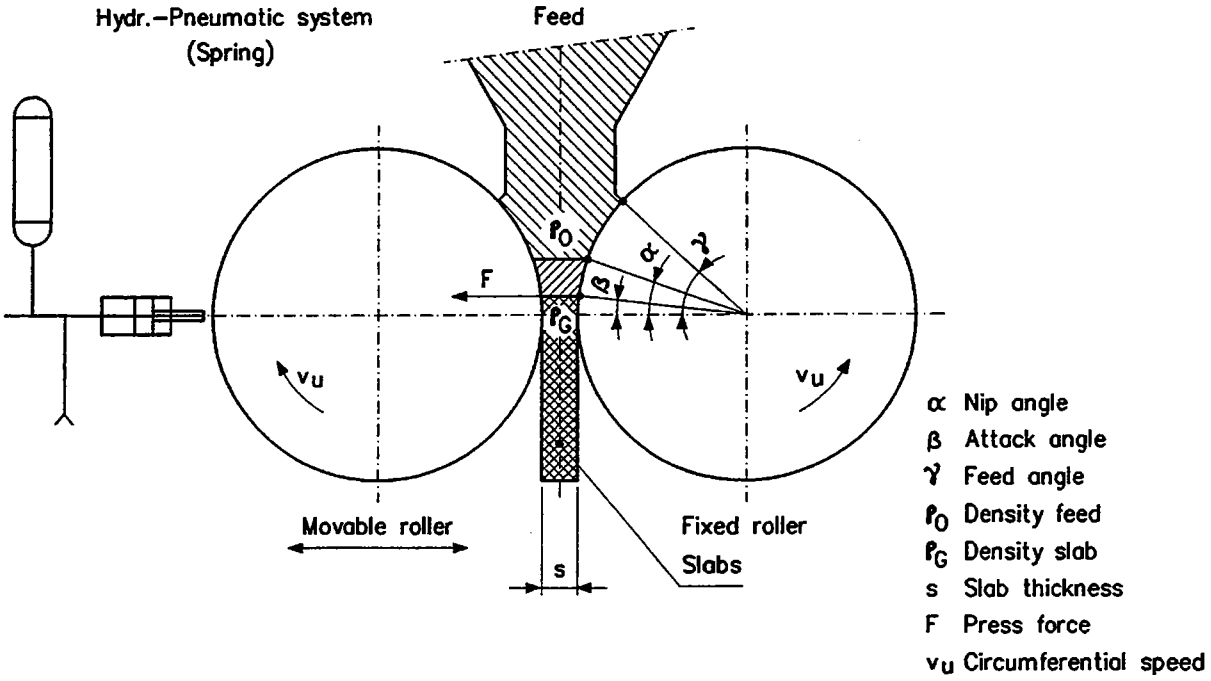
2.2 Working Principle (Figure 2)

Bulk material is fed to the gap between two rollers which are driven in counter-rotation. The necessary press force is created by a hydraulic-pneumatic system which works like a spring.

- Feed
  It is distinguished between choke feed and starved feed.
  - Choke feed: A column of material lays over the rollers. In this case, in order to assure smooth operation, it is very important that the material is deareated before it enters the gap. The choke feed is the common solution.
  - Starved feed: The feed is dosed into the gap (no material column). The advantage is that the air can easily escape, however, this solution requires a very accurate dosing equipment.
- Pressing process (size reduction)
  - The compaction of the material with the density ρo starts at the nip angle α. The maximum is achieved at the so called attack angle β (center of pressure) where the material reaches the slab density ρ_G.
  - Between α and β an interparticle comminution takes place where each particle transmits the force imposed on it to another particle. Best results are achieved with materials of wide particle size distribution with a maximum filling of the voids. In the pressing process a simple size reduction takes place but also flaws and fissures within the particles are produced reaching into the micro range.

- Product
  - The material leaves the press in form of slabs which normally have the gap thickness **s**. For further processing these slabs must often be desagglomerated.

Figure 2 Working Principle



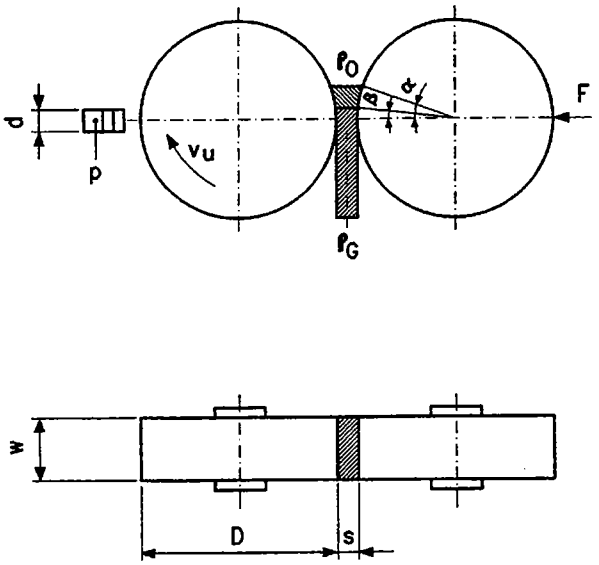
3. DIMENSIONING AND DIMENSIONING CRITERIA (FIGURE 3 AND 4)

Of interest for the user of a roller press are the calculation of the press throughput, the press force, the absorbed power and the specific energy consumption. For projects and comparison of presses further calculations are used such as specific press force and specific surface load.

- Press throughput ❶
  The throughput is given by the dimensions of the press and the density of the slab. This density is dependent on the operating parameters (e.g. pressure) and the feed material. The gap opening is a function of the material, roller diameter and roller surface and varies between 15 and 45 [mm]. Guide values for ρ_G are:
  - Clinker 2.4 - 2.5 [t/m^3]
  - Raw material 2.3 - 2.4 [t/m^3]
  - Slag 2.2 - 2.3 [t/m^3]
- Press force ❷
  The press force is given by the number and diameter of the hydraulic cylinders and the operating pressure. The operating pressure varies from supplier to supplier.

- Absorbed motor power ❸
  The absorbed motor power can be calculated by means of the press force, the circumferential speed of the rollers and the attack angle β.
  The attack angle β is dependent on the roller diameter, the gap opening and the material.
  Guide values for β are:
  - Clinker 2.3 - 2.85 [°]
  - Raw material 2.85 - 4 [°]
  - Slag 1.7 - 2.3 [°]

Figure 3 Dimensioning



Symbol	Designation	Unit
$\dot{M}$	Press throughput	(t/h)
$\dot{G}$	Product	(t/h)
D	Roller diameter	(mm)
w	Roller width (Slab width = Roller width)	(mm)
s	Slab thickness	(mm)
v_u	Circumferential speed	(m/s)
ρ_G	Density slab	(t/m³)
ρ_0	Density feed	(t/m³)
F	Press force	(kN)
d	Diameter hydr. cylinder	(mm)
z	Number hydr. cylinders	(–)
p	Hydr. pressure	(b)
K	Spec. press force	(kN/m²)
L	Spec. surface load	(N/mm²)
P	Abs. motor power	(kW)
E	Spec. energy consumption	(kWh/t)
α	Nip angle	(°)
β	Attack angle	(°)
u	Circulating factor	(–)

- Specific press force ❹
  - The specific press force is the press force divided by the projected roller area. Most suppliers allow a specific press force of ~ 8500 [kN/m²].
  - In order not to overstress the wear protection on the rollers, HMC recommends ~ 6000 [kN/m²] (to be subjected to further discussion).
- Specific surface load ❺
  The specific surface load is the press force divided by the part of the roller surface which is under pressure. This load should not exceed 250 [N/mm²] (to be subjected to further discussion).
  Guide values for α are:
  - Clinker 6.9 - 9.2 [°]
  - Raw material 9.2 - 12.6 [°]
  - Slag 5.7 - 7.5 [°]

- Specific energy consumption ❻ ❼
  - The specific energy consumption **E** is based on press throughput. Guide values are:
    - Clinker 2.5 - 3 [kWh/t]
    - Raw material 2.0 - 2.5 [kWh/t]
    - Slag ~3 [kWh/t]
  - If a press is in closed circuit with a separator (finish grinding) or has a slab recirculation the specific energy consumption is multiplied by the circulating factor **u**.
  - The specific energy consumption **Ec** is then based on the material leaving the press circuit.

Figure 4 Dimensioning

① Press throughput

$$\dot{M} = \frac{w \cdot s \cdot v_u \cdot \rho_G \cdot 3{,}6}{1000} \quad (t/h)$$

② Press force

$$F = \left(\frac{d}{1000}\right)^2 \cdot \pi \cdot z \cdot p \cdot \frac{100}{4} \quad (kN)$$

③ Absorbed motor power

$$P = \frac{2 \cdot F \cdot \beta_{rad} \cdot v_u}{\eta} \quad (kW)$$

η Efficiency gear and motor

④ Specific press force

$$K = \frac{F \cdot 10^6}{D \cdot w} \quad (kN/m^2)$$

⑤ Specific surface load

$$L = \frac{F \cdot 10^3}{w \cdot \frac{D}{2} \cdot \alpha_{rad}} \quad (N/mm^2)$$

⑥ ⑦ Specific energy consumption

$$E = \frac{P}{\dot{M}} \quad (kWh/t)$$

$$E_C = \frac{P \cdot u}{\dot{M}} \quad (kWh/t)$$

4. OPERATIONAL ASPECTS

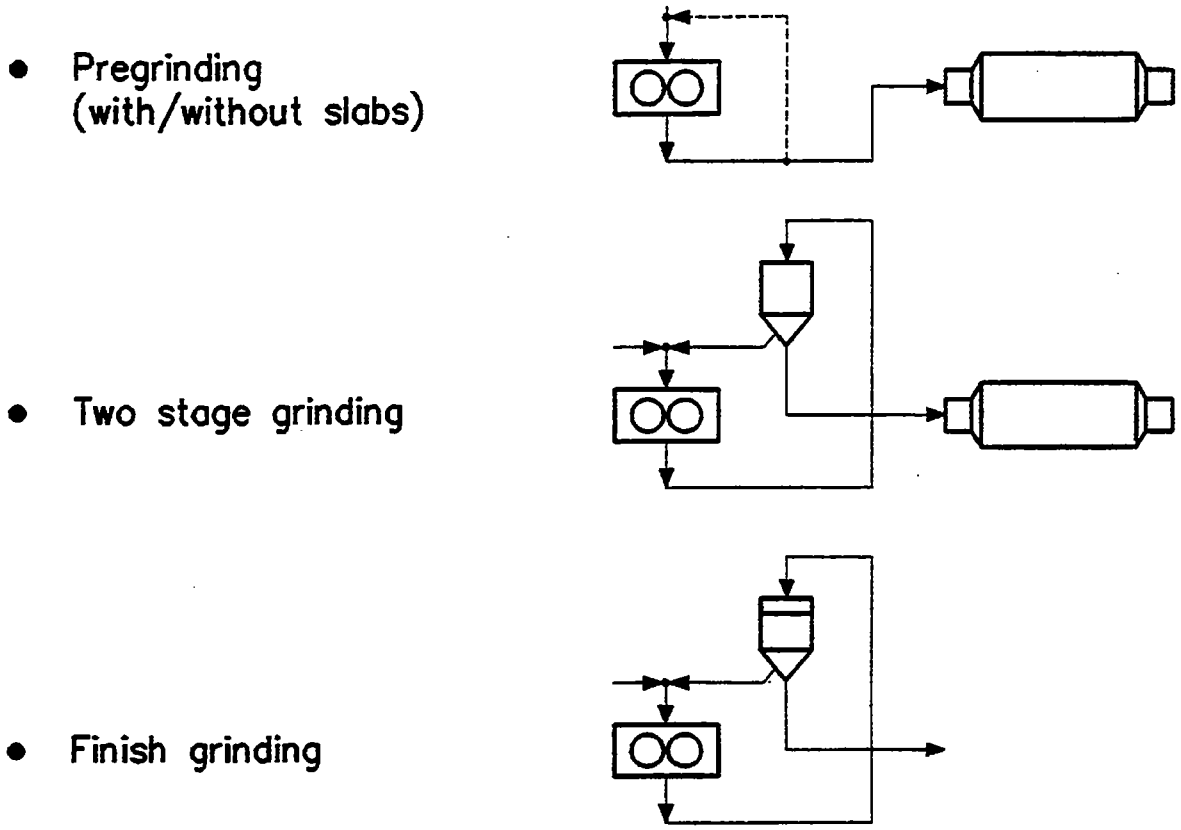
4.1 Installation of Roller Press (Figure 5)

The roller press can be installed in various configurations.

- In combination with tube mill
  - Roller press as pregrinding unit
  - Roller press as pregrinding unit with slab recirculation
  - Two stage grinding system (semi-finish)

- Finish grinding system
  - The roller press is in closed circuit with a desagglomerator and a separator
- The detailed description with advantages and disadvantages is given in the paper VA 93/4014/E, Cement grinding systems.

Figure 5 Installation of Roller Press



4.2 Feed Granulometry and Roller Speed (Figure 6)

The maximum feed size depends on the roller diameter, the roller surface and the supplier. Up to 50 [mm] is a normal given maximum size.

A commonly used value is also

- max feed size = 2 x gap opening

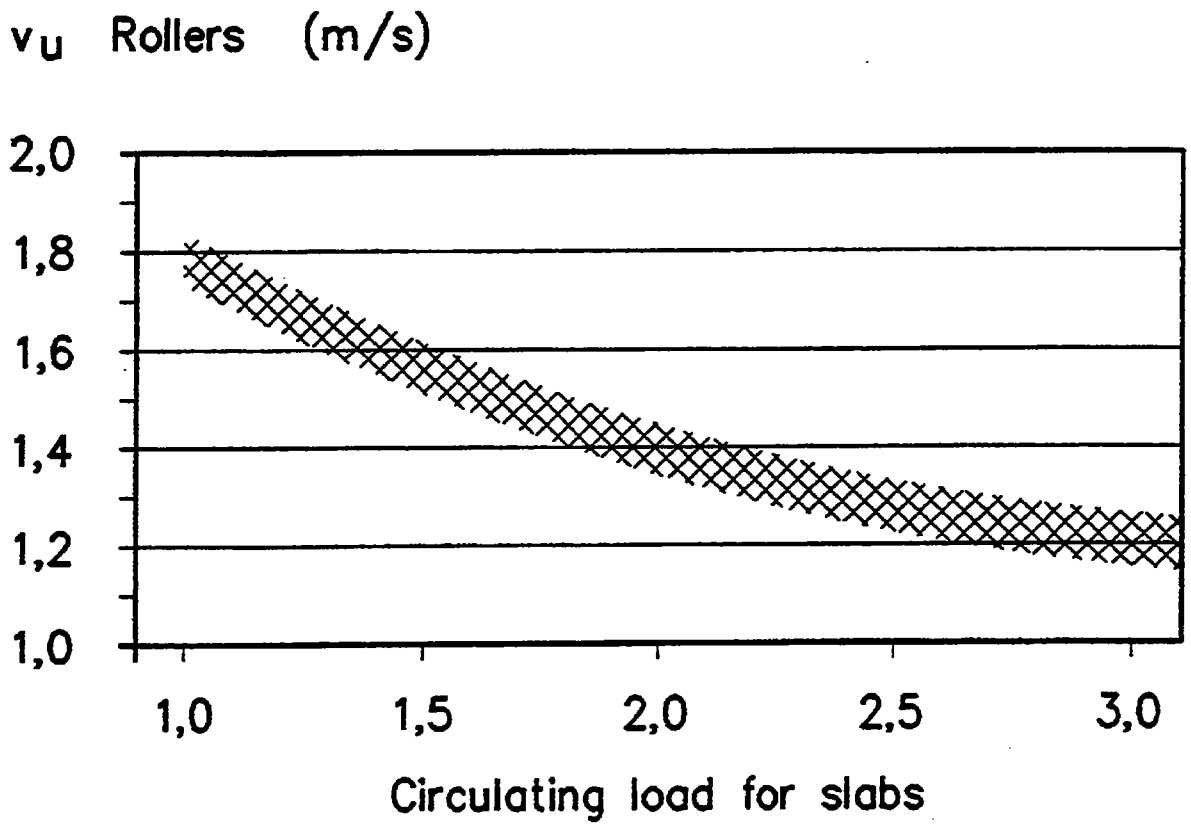
A strong relation exists between the granulometry of total feed and the circumferential speed of the rollers. If the feed contains a high amount of very fine material and the speed of the rollers is high (~ 1.8 m/s) the press tends to vibrate and a smooth operation is not possible.

- Pregrinding without slab recirculation
  Coarse feed to the press, vibration normally not a problem.
- Pregrinding with slab recirculation
  This is the critical case since the slabs contain a high amount of fine material. Figure 6 shows the relation between circumferential speed and circulating load. At a circulating load of 2 (total feed : product) the roller speed should not exceed 1.5 - 1.55 [m/s].

- Two-stage and finish grinding system
  Not critical since the return from the separator does not contain very fine material.

The speed range of the "Holderbank" roller presses is 1 - 1.55 (m/s).

Figure 6 Circumferential Speed of Rollers



4.3 Adjustable Feed Gate (Figure 7 and 8)

An important influence on the press operation (material intake, gap opening) has the feed gate. All press manufacturers supply their presses with adjustable feed gates. A very sophisticated gate is shown in Figure 7.

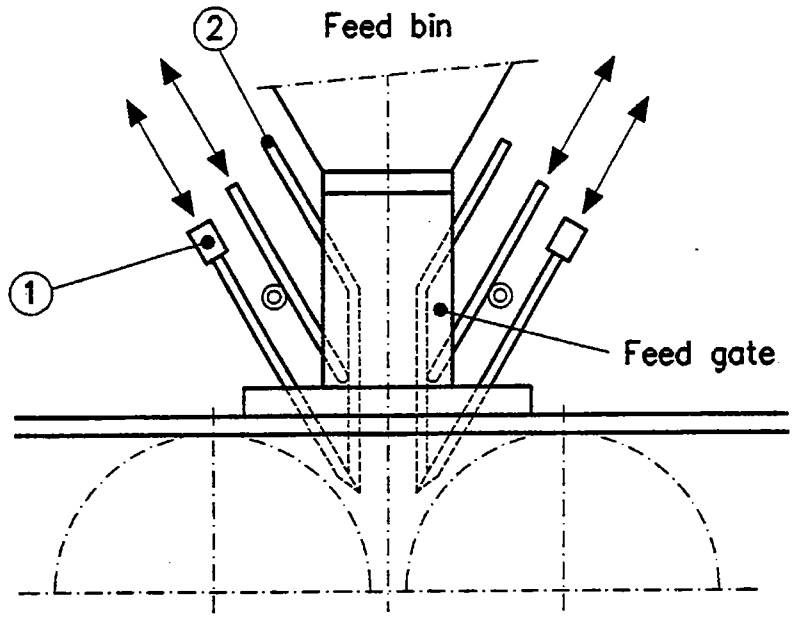
Functioning

- Lower gate 1: The two tongues have only an open or closed position. With this feature the feed to the press can be interrupted and the press be stopped with a full feed bin. (hydraulically or pneumatically activated).
- Upper gate 2: This is the real adjustable feed gate which allows:
  - Flow regulation to the press (changing chute opening)
  - Excentrical distribution of the material
  - This part of the gate can also be motorized or kept manually, e.g.:
    * fixed roller side manually
    * movable roller side motorized

Figure 8 shows a typical example how the gap opening can be influenced by the position and the opening of the gate. Very often best results are achieved if the opening is moved towards the fixed roller and with this position also equal power draw of the rollers is achieved.

The best position must be found by trials.

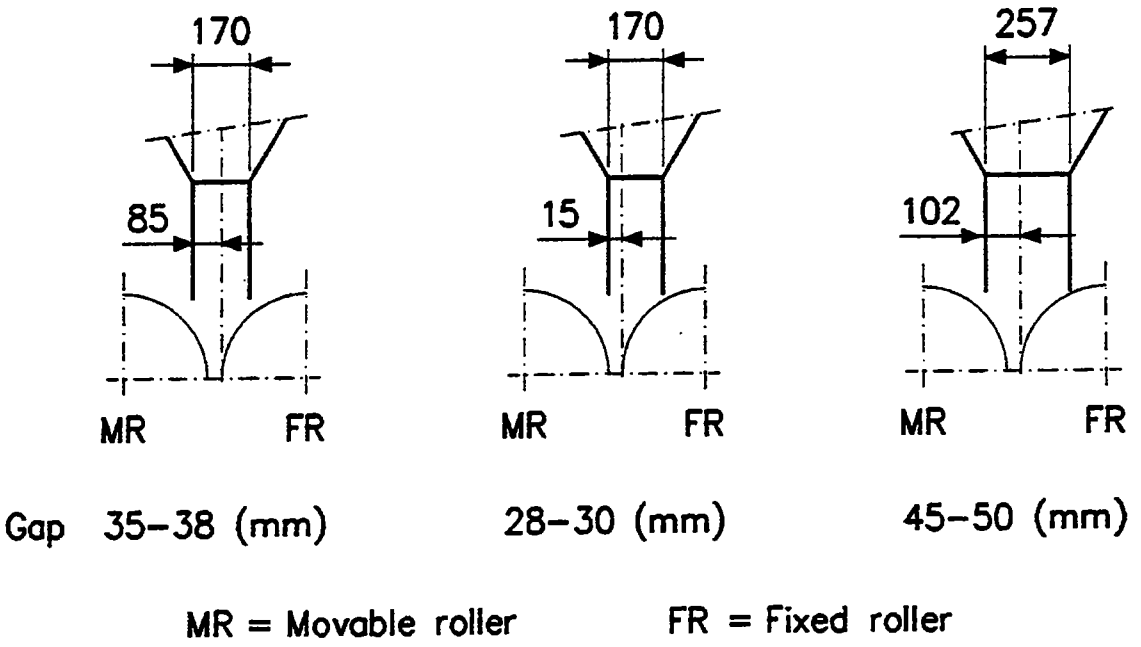
Figure 7 Adjustable Feed Gate



(1) Lower gate, open – closed position

(2) Upper gate, continuously adjustable

Figure 8 Influence on Gap Opening



4.4 Operating Parameters (Figure 9)

The degree of comminution depends on the specific energy which is transmitted into the material. As shown in chapter 3 - Dimensioning - the absorbed power of the press is linear to the press force applied and the latter is linear to the operating pressure. The operating pressure can mainly be influenced by 3 parameters which are:

- Accumulator, nitrogen charge setting (initial)
- Hydraulic system, set point pressure
- Initial gap, zero setting of gap

The following relations exist:

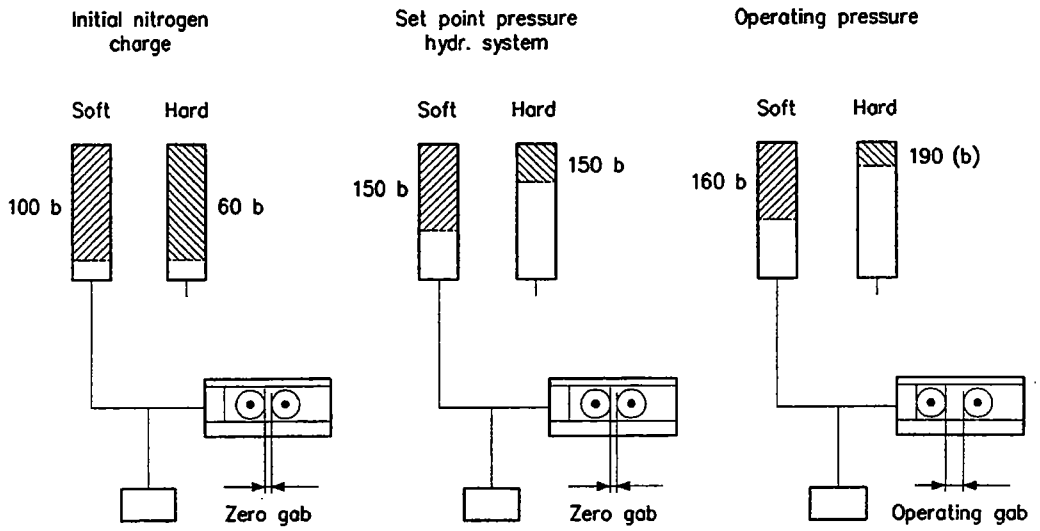
- Initial nitrogen pressure < set point pressure hydraulic system < operating pressure
- If a large difference exists between initial nitrogen pressure and set point pressure hydraulic system the accumulators work like a hard spring.
  If a small difference exists between initial nitrogen pressure and set point pressure hydraulic system the accumulators work like a soft spring.

The press force (operating pressure) can be increased by (or vice versa):

- Reduction of initial nitrogen pressure
  - Set point hydraulic pressure kept constant
  - Zero gap setting not changed
- Increase of set point hydraulic pressure
  - Initial nitrogen pressure kept constant
  - Zero gap setting not changed
- Zero gap setting increased
  - Initial nitrogen pressure kept constant
  - Set point hydraulic pressure kept constant

The most efficient working point (absorbed power, hard or soft spring) must be found during commissioning by trials.

Figure 9 Operating Parameters



5. MECHANICAL ASPECTS (FIGURES 10 AND 11)

5.1 Wear

Wear on a roller press mainly occurs in the feed chute on the roller surface and on the cheek plates. The wear rate depends on the feed material (abrasiveness, moisture etc.) and on the operating parameters of the press.

5.1.1 Rollers

The wear rate itself on the rollers is low (for clinker 1-2 g/t) and does not present a problem, however, the entering of foreign matters (grinding balls, metal pieces etc.) can lead to the destruction of the roller surface. The improvement of the resistance of the roller surface is still an ongoing process and no final solution is found.

5.1.1.1 Welded protection (common solution)

The welding consists of buffer layers and hard facing. The so called "peeling off" takes often place if metal pieces enter the press (large pieces of welding are falling off). Smaller repair work can be done in the press. Reconditioning should be made in a workshop.

5.1.1.2 Stud lining

KHD introduced this type of protection.

Wear resistant studs are welded onto the rollers.

The roller body is protected by the feed material which is pressed into the voids between the studs. The reliability of this solution must still be proven.

5.1.1.3 Clamped on tyres

No experience available

5.1.1.4 Clamped or bolted on segments

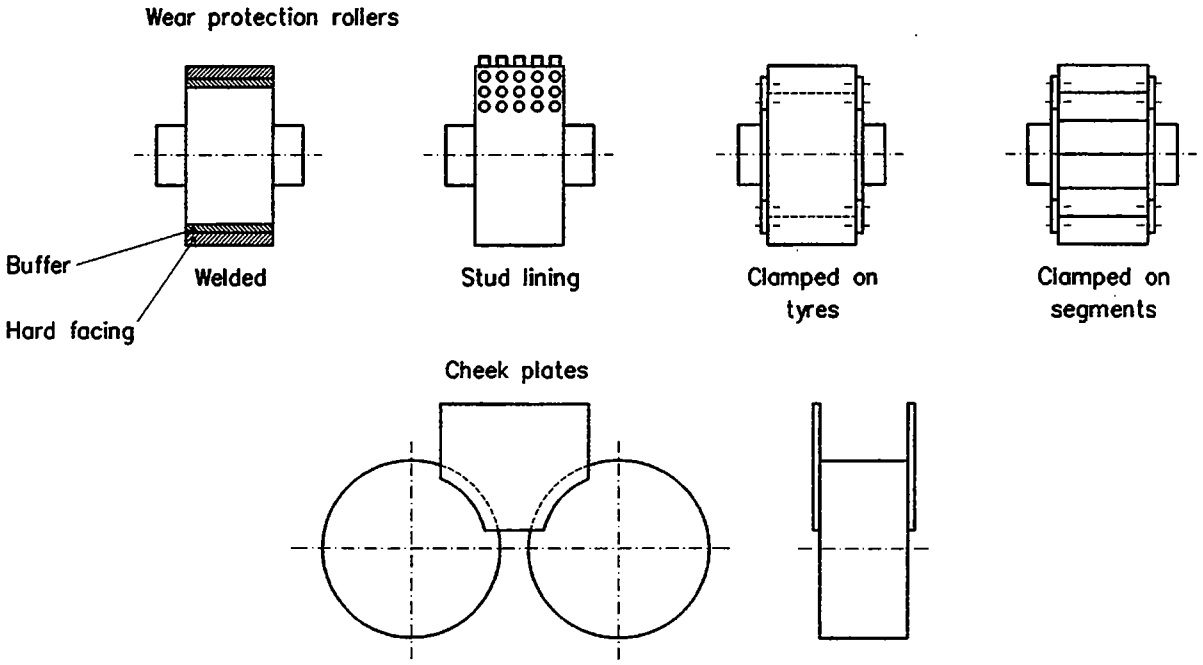
This solution reduces mainly the down time of the press if a damage occurs.

This is a fairly new approach and not enough experience is available. However, a trend can be seen towards this solution.

5.1.2 Cheek plates

The function of the plates is to avoid the escape of material sidewards from the rollers. They are made from wear resistant material and are easily exchangeable.

Figure 10 Mechanical Aspects



5.2 Press Protection (Figure 11)

In order to keep the risk of roller surface damages as low as possible all foreign matters must be removed from the press feed (fresh feed and recirculating material). The feed material must pass below an electromagnet and a metal detector. The detector is linked to a by-pass gate. Metals which are not removed by the magnet will be detected by the metal detector and will by-pass the roller press.

Some presses have in addition a screen between clinker storage and press feed bin for a first separation of large foreign matters and oversized feed.

5.3 Movable Feed Bin

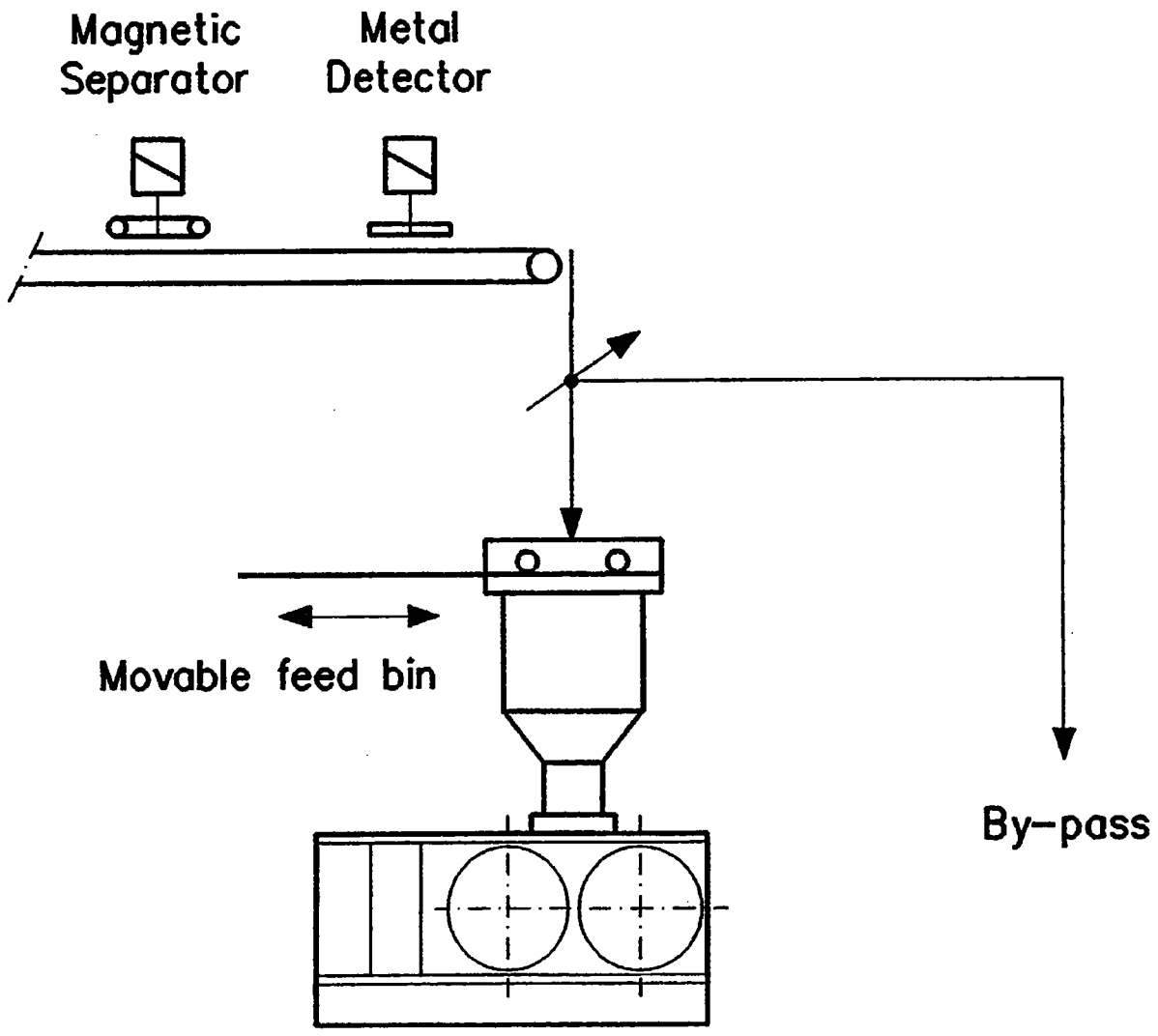
In order to simplify the disassembly of the rollers and to do major repairwork on the press the installation of a movable feed bin is advantageous.

5.4 Inspections

A continuous operation of a roller press can only be achieved if the critical areas or parts of the press are regularly inspected and serviced.

- During operation
  - Vibrations of press and press drive
  - Bearing and oil temperatures (if oil lubricated)
  - Lubrication system
- During stop
  - Wear parts (rollers, cheek plates, inside feed chute)
  - Bearings and bearing sealings
  - Lubrication system, water cooling system
  - Hydraulic system, pressure setting accumulators
  - Drive including gear boxes, shafts, clutches, electrical motors

Figure 11 Press Protection



6. MAIN SUPPLIERS

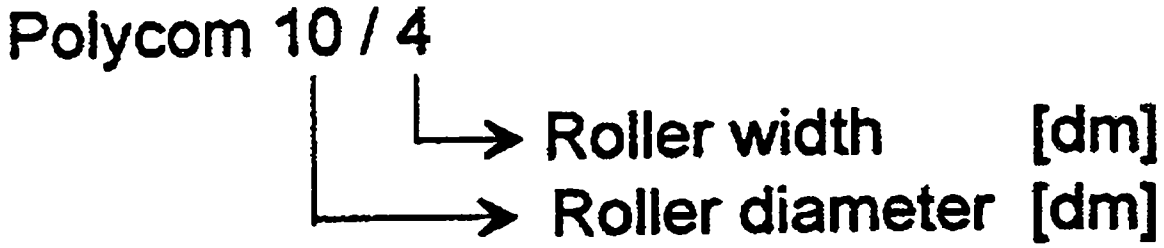
6.1 Krupp - Polysius (Figure 12)

6.1.1 General

Krupp - Polysius, besides KHD, is mainly responsible for the design, application and further development of the roller press.

6.1.2 Make:

Make **Polycom 10 / 4**



6.1.3 Standard sizes: 9

Power range:	300 - 2500	[kW]
Throughput:	90 - 700	[t/h] clinker
Specific press force:	~ 6500	[kN/m^2]

6.1.4 Design features

Frame: Bolted design, on the fixed roller side a slide block can be added to the press in order to remove the rollers (both on one side).

Rollers: Wear protection by hard face welding, tyres or segments, water cooling of shaft standard outfit.

Roller bearings: Self aligning spherical roller bearings with grease lubrication.

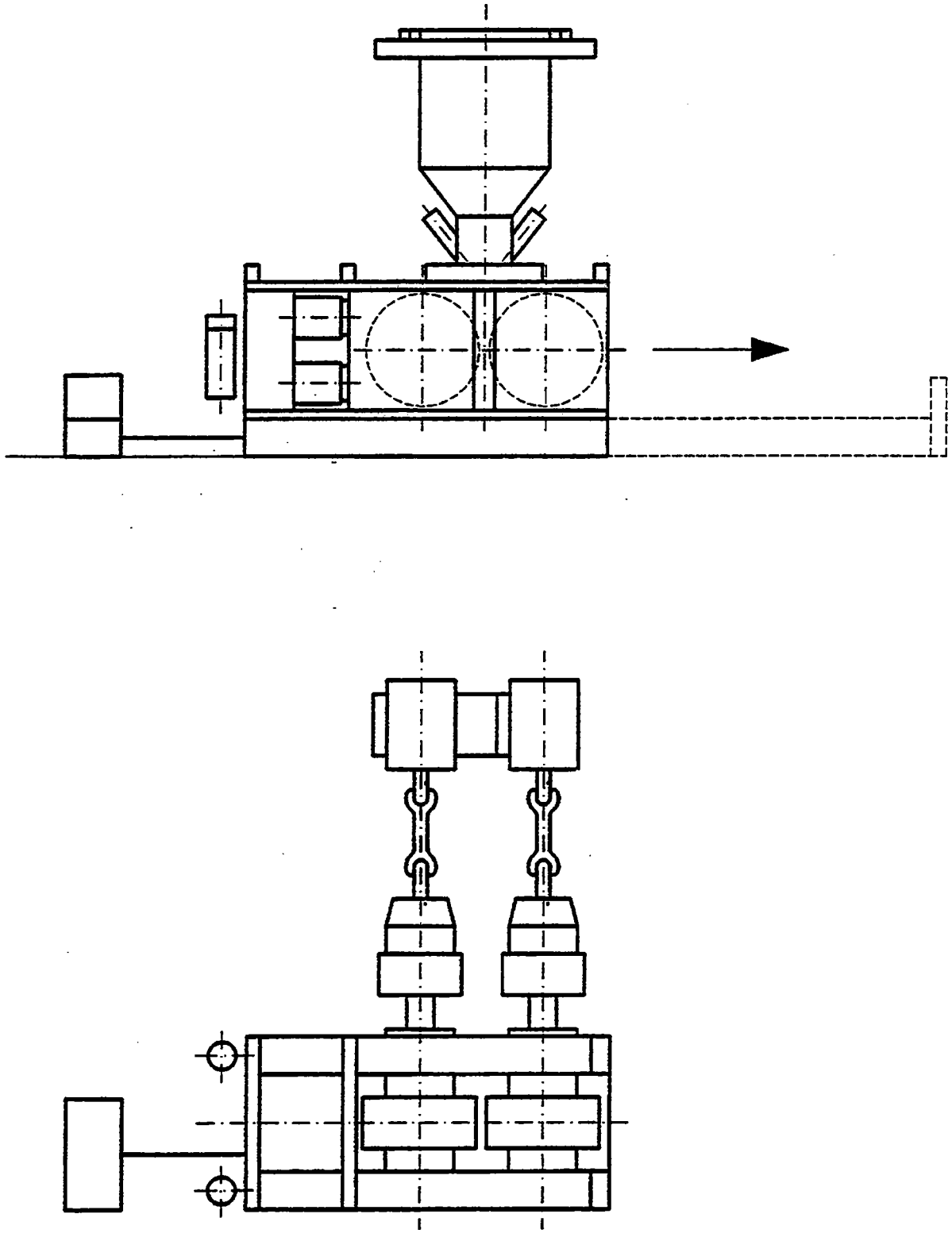
Hydraulic system: 2 x 2 hydraulic cylinders and on each side one nitrogen accumulator.

Drive system (both rollers identical): Shaft mounted planetary gear with torque arm, safety coupling; universal joint and electrical motor.

6.1.5 Experience

Very experienced supplier, wear protection rollers still in a development phase.

Figure 12 Krupp Polysius



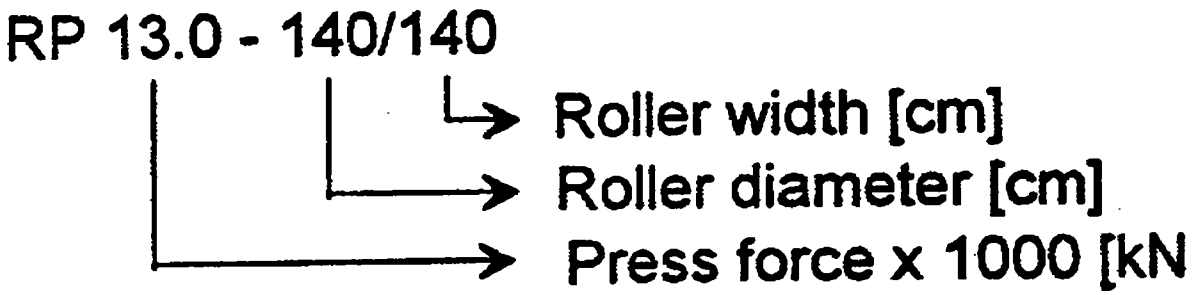
6.2 KHD - Humboldt Wedag (Figure 13)

6.2.1 General

Same comment as for Krupp-Polysius

6.2.2 Make:

Make **RP 13.0 - 140 / 140**



6.2.3 Standard sizes: 7 (various speeds within each size)

Power range: 150 - 4200 [kW]

Throughput: Not specified

Specific press force: ≤ 7000 [kN/m^2]

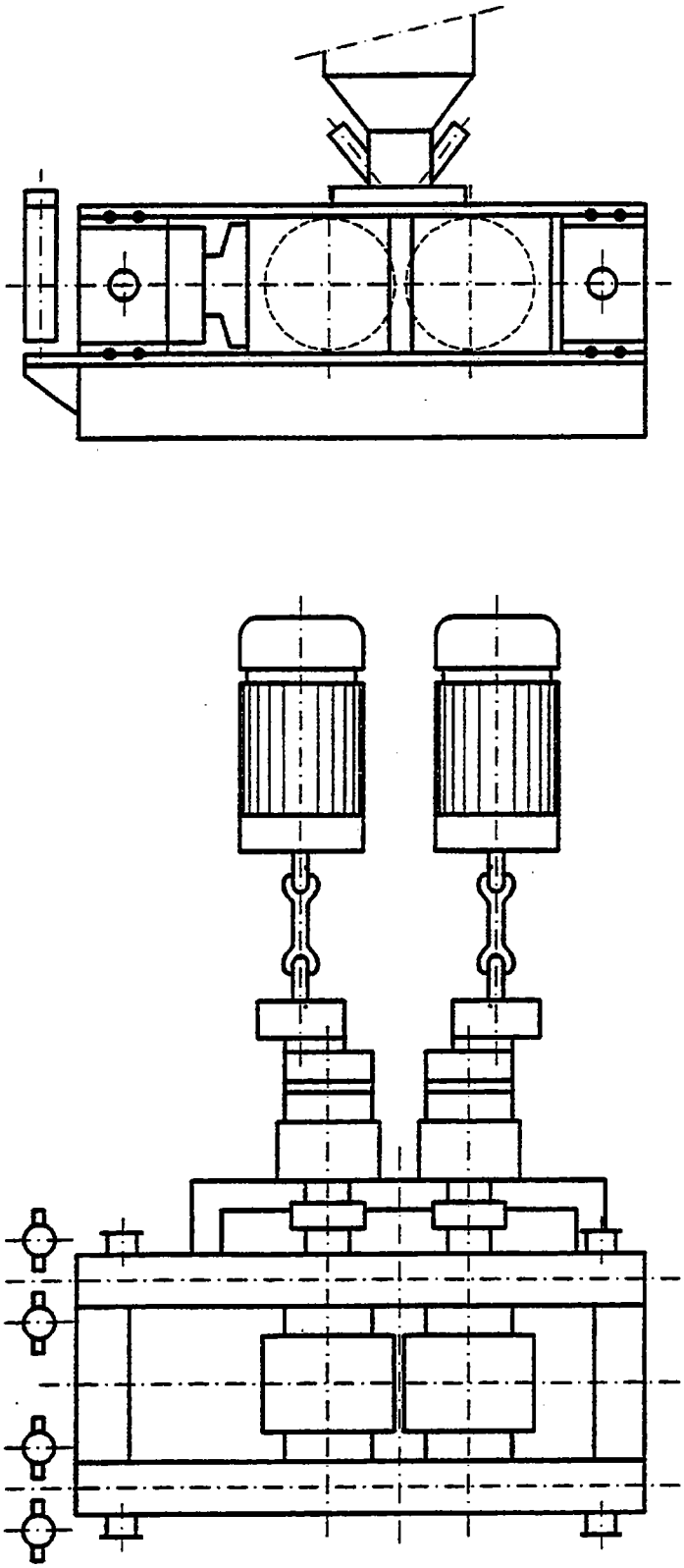
6.2.4 Design features

- Bolted design: Feed chute and top girders must be dismantled for removing rollers.
- Rollers: Wear protection by hard face welding, welded on studs or segments with welded on studs, water cooling of shaft standard outfit.
- Roller bearings: Cylindrical roller bearings with oil lubrication.
- Hydraulic system: One large hydraulic cylinder on each side including three nitrogen accumulators (2 large, 1 small).
- Drive system (both rollers identical).
  Shaft mounted planetary gear with torque arm, fluid coupling, universal joint and electrical motor.

6.2.5 Experience

Very experienced supplier, wear protection rollers still in a development phase.

Figure 13 KHD Humboldt Wedag



6.3 F.L. Smidth-Fuller (Figure 14)

6.3.1 General

In earlier days FLS sold the Köppern roller press. Fuller manufactured their own roller press.

The newest design is a combined FLS-Fuller press

6.3.2 Make:

HRP 1.25

Projected roller area

Standard sizes: 8

Power range:	503 - 3024	[kW]
Throughput:	167 - 995	[t/h] (clinker)
Specific press force:	8000	[kN/m2]

6.3.3 Design features

- Frame: Bolted design, one side can be hinged down for removing the rollers.
- Rollers: Wear protection by hard face welding or segments, optional with water cooling for shaft.
- Roller bearings: Self aligning spherical roller bearings with oil lubrication.
- Hydraulic system: 2 x 2 hydraulic cylinders.
- Drive system movable roller: Shaft mounted planetary gear with torque arm, universal joint shaft, mechanical torque limiting coupling, electrical motor (preferred SC motor slip ring type).
- Drive system fixed roller: Double gear type transmission shaft, foot mounted planetary gear, torque limiting coupling, electrical motor.

6.3.4 Experience

New press, however, proven standard elements are used.

Figure 14 F L Smidth - Fuller